

NAVAL HEALTH RESEARCH CENTER

MARINE CORPS CASEVAC: DETERMINING MEDICAL SUPPLY REQUIREMENTS FOR LONG-RANGE CASUALTY EVACUATION AIRCRAFT

***M. Hill
P. Konoske
M. Galarneau
G. Pang***

Report No. 03-20

Approved for public release; distribution unlimited.



**NAVAL HEALTH RESEARCH CENTER
P. O. BOX 85122
SAN DIEGO, CA 92186-5122**

**BUREAU OF MEDICINE AND SURGERY (M2)
2300 E ST. NW
WASHINGTON, DC 20372-5300**



MARINE CORPS CASEVAC:

Determining Medical Supply Requirements for Long-Range Casualty Evacuation Aircraft



Martin Hill¹
Mike Galarneau²
Gerry Pang²
Paula Konoske²

¹GEO-CENTERS, Inc.
7 Wells Avenue, Suite 1
Newton, MA 02459

²Naval Health Research Center
P.O. Box 85122
San Diego, CA 92186-5122

Technical Report No. 03-20 was supported by the Bureau of Medicine and Surgery, BUMED-26, Washington, DC and the Marine Corps Systems Command, Quantico, VA, under Work Unit 63706N M0095.005-60120. The views expressed in this article are those of the authors and do not reflect the official policy or position of the Department of the Navy, Department of Defense, or the U.S. Government. Approved for public release; distribution unlimited. This research has been conducted in compliance with all applicable federal regulations governing the protection of human subjects in research.

TABLE OF CONTENTS

Summary	iii
Introduction	1
Method	2
CASEVAC Aircraft	2
Clinical Requirements	3
Results	11
Discussion and Conclusions	10
Aeromedical Considerations	10
Flight Crew Considerations	11
Equipment Transportation Considerations	12
References	14
Appendix A: CASEVAC Patient Conditions	A-1
Appendix B: CASEVAC Generic Patient Types	B-1
Appendix C: CASEVAC Generic Treatment Briefs....	C-1

SUMMARY

Problem

Providing casualty evacuation (CASEVAC) in the modern high-maneuver combat environment presents special problems. Small mobile units operating at increased distances from rear areas or sea-based platforms likely will not have the support of a Level 1B treatment facility, such as a battalion aid station. With combat elements positioned far forward of their support units, ground evacuation may be impractical. Even evacuation by air may take more than the “Golden Hour” by which time trauma experts agree severely injured patients must receive some form of advanced lifesaving intervention. Needed is a specially equipped aeromedical asset manned by corpsmen with appropriate skill levels to provide the necessary critical care interventions to stabilize severely wounded, injured or ill Marines for a period of transit that could last hours.

Objective

The objective of this study was to determine what level of medical skills and what kind of medical equipment would be required for such a CASEVAC asset.

Method

Thirty-one generic CASEVAC patient types were developed from the Joint Readiness Clinical Advisory Board’s list of patient conditions. Treatment profiles were written for each patient type and medical supplies assigned to each task in the treatment profiles, establishing the clinical requirements for the CASEVAC supply blocks.

Discussion and Conclusion

The Marine Corps needs to establish a long-range CASEVAC capability to provide critical care intervention to wounded Marines and sailors. This study has identified the clinical task skills, equipment and medications needed to provide that care. In doing so, the study has also identified the training level needed for the medical flight crew. Two senior search and rescue medical technicians, trained in advanced life support and critical care skills, appear best suited to the medical care required by this CASEVAC asset.

Marine Corps CASEVAC: Determining Medical Supply Requirements for Long-Range Casualty Evacuation Aircraft

INTRODUCTION

Sea Power 21 doctrine calls for projecting U.S. military power from sea-based command platforms far into any future battle space, thus maintaining reduced personnel, equipment and logistical footprints ashore. As part of this doctrine, the U.S. Marine Corps is developing capabilities to deploy and support combat troops for short-duration, high-maneuver missions, often deep within enemy territory and far from shore.¹ Included in this capability is the use of company-size (150 men) raiding parties from special operations capable Marine Expeditionary Units [MEU (SOC)] for forays extending up to 400 miles from their over-the-horizon support units.²

Providing casualty evacuation (CASEVAC) in this emerging combat environment presents special problems. Small mobile units operating at increased distances from rear areas or sea-based platforms likely will not have the support of a Level 1B treatment facility, such as a battalion aid station. With combat elements positioned so far forward, ground evacuation is impractical given the extended time such transport would take. At such distances, even evacuation by available air assets — such as the CH-53 Sea Stallion and its variants, and the CH-46 Sea Knight and its variants — would be well outside the “Golden Hour” by which time trauma experts agree severely injured patients must receive some form of advanced lifesaving intervention.^{2,3}

The multi-service Committee on Tactical Combat Casualty Care has determined such highly mobile battle tactics as special operations require a means of providing intermediate to advanced casualty care during prolonged CASEVAC transportation. Needed is a specially-equipped aeromedical asset manned by a corpsman with appropriate critical care skill levels to provide the necessary interventions to stabilize severely wounded, injured or ill Marines for prolonged transport.⁴ While such a capability does not currently exist for the Marine Corps, the 24th MEU (SOC) has designated a CH-53 Sea Stallion as a long-range CASEVAC platform to provide advanced trauma life support (ATLS) for up to 16 wounded Marines.^{2,3} This platform, however, currently cannot be supported with existing material and personnel resources.²

To address this deficiency, the 24th MEU (SOC) had drafted and submitted a Universal Needs Statement (UNS) to the Marine Corps Combat Development Command.² It is the objective of the current study to conduct an empirical assessment of the clinical requirements needed to support the type of CASEVAC mission identified in this UNS.

METHOD

CASEVAC Aircraft

Before the clinical requirements could be assessed, the type of aircraft available for CASEVAC missions and their capabilities and limitations had to be reviewed. An aircraft's noise and vibration levels, interior space restrictions, and flight speed have a direct impact on the selection of equipment used on board, as well as the skill levels required by the corpsman manning the asset.

The Marine Corps does not have dedicated casualty evacuation aircraft. Those aircraft available for CASEVAC missions are assigned on an as-needed or "lifts of opportunity" basis. For this study, four types of Marine Corps aircraft were deemed available for future CASEVAC missions — two variants of the CH53, the CH46E, and the tilt-rotor MV-22 Osprey, still in development. The capabilities of these aircraft are described in Table 1.

Table 1. Aircraft Characteristics

Capability	MV-22	CH53D	CH53E	CH46E
Primary Function	Medium-lift equipment, supplies & personnel transport	Medium-lift equipment, supplies & personnel transport	Heavy-lift equipment, supply & personnel transport	Medium-lift assault helicopter
Crew (normal/combat)	4/4	3/3	3/3	4/5
Litters	12	24	24	15
Ambulatory	24	55	55	15
Force of blades	Extreme	Moderate	Moderate	Moderate
Temperature	Heating, no A/C	Heating, no A/C	Heating, no A/C	Heating, no A/C
In-flight refueling	Yes	No	Yes	No
Range (nm)	515	600	540	132
Speed (kts)	275	130	150	145
Altitude (ft)	25,000	10,000	10,000	10,000
On-board oxygen generation	Crew only	No	No	No
Takeoff weight (lbs.)	47,500	42,000	69,700	24,300
All weather	Yes	Yes	Yes	Yes

The newest of these, the MV-22 Osprey tilt rotor aircraft is being developed to replace the older CH53s and CH-46s in multiple combat operational roles. Depending on configuration, the MV-22 can hold 24 seats or 12 litters, the CH-53D Sea Stallion and CH-53E Super Stallion can hold 55 seats or 24 litters, and the CH-46E can hold 14 seats or 15 litters.

Only the Osprey and the Super Stallion have in-flight refueling capabilities and, thus, the capability of extending their maximum flight ranges of 515 nautical miles and 540 nautical miles, respectively. This makes those two aircraft the most likely candidates for use in long-range missions broaching the maximum penetration distance of 400 miles described in the UNS.

All four of the Marine Corps aircraft identified above are unpressurized. Only the MV-22 has an on-board oxygen generating system for crew use. Noise levels vary in all of the aircraft due to conditions such as engine size and speed, rotors, pressure altitude, and station location. Noise levels are unacceptable for unprotected personnel.

Patients are positioned along the outboard side of the aircraft. Litter stanchions are configured along the outboard side so that the litters are against the fuselage wall. Patients with monitoring equipment or treatment devices may necessitate the litter position above them remain empty.

Though the Osprey has nearly twice the speed of the other three aircraft, the averaged maximum air speeds of the Sea Knight and Sea Stallion were used in this study to compute the transit time from casualty pick-up in the field to delivery to a medical facility, usually aboard a casualty receiving and treatment ship offshore. An average length of stay aboard the CASEVAC aircraft of 4 hours for the maximum 400-mile distance identified in the UNS was arrived at to allow for headwinds that might slow the CASEVAC aircraft and prolong flight time.

This long transport time, along with the severe limitations on treatment created by the environmental factors within the aircraft, contributed to selecting which life-sustaining skills should be expected of the CASEVAC medical crew.

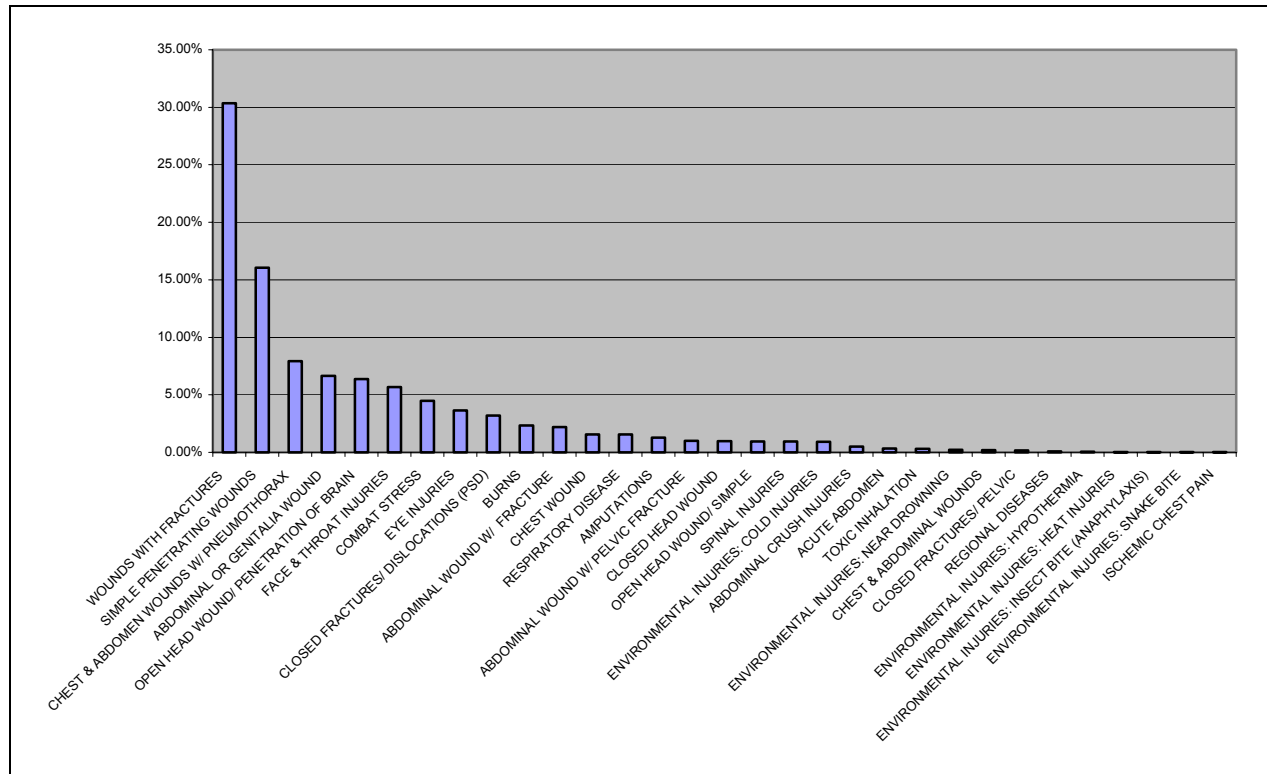
Clinical Requirements

The Naval Health Research Center (NHRC) method of modeling medical supply requirements has been used to establish and/or review Authorized Medical Allowance Lists for various levels of care in the Navy and the Marine Corps.⁵ It involves a four-step process that begins with the identification of likely patient types to be encountered, including combat wounds, nonbattle injuries, and illnesses. Patient conditions (PCs) found in the Joint Readiness Clinical Advisory Board (JRCAB) treatment briefs were used for this purpose. One hundred and ninety-nine PCs were identified as those most likely to be encountered by a CASEVAC medical crew (see Appendix A). For modeling purposes, these JRCAB PCs were distributed into 31 generic patient types divided into three categories – trauma, environmental injury, and illness (see Appendix B).

The underlying probability of the selected JRCAB PCs occurring in a given battle was determined by running a patient stream containing the PCs through the NHRC Estimating Supplies Program, using a combined East-West battle scenario incorporating a Northeast Asia Heavy Battle Intensity and Southwest Asia Heavy Battle Intensity. Once the probability of the individual PCs was determined, the underlying probability for each

of the generic CASEVAC patient types was calculated. The generic patient types and their probabilities are seen in Table 2.

Table 2. Occurrence of CASEVAC Generic Patient Types



Once the generic patient types were identified, generic treatment briefs based on the JRCAB treatment guidelines were written for each one. Each brief included a description of the patient's injuries or illness, clinical condition including vital signs, and the required medical tasks to be performed to treat each patient type. These generic treatment briefs can be found in Appendix C.

A brief profile was created for each generic patient type. The task profiles include the unique clinical interventions required by each patient type, and establish a systematic sequence of clinical tasks to be performed by the attending corpsmen. Forty-nine clinical tasks were identified (Table 3). These clinical tasks were compared with the 12 major categories of clinical skills recommended for CASEVAC care by the multi-service Committee on Tactical Combat Casualty Care and found to encompass all skill categories.⁴

Table 3. CASEVAC Clinical Tasks

Task	Task Description
002	Assessment and Evaluation of Patient Status
006	Establish Adequate Airway (Oro/Naso Pharyngeal only)

Task	Task Description
007	Emergency Cricothyroidotomy
010	Neurological Assessment
011	Stabilize Neck (Collar/Spine Board)
018	Recognize and Respond to Hemorrhage
022	O2 Administration Setup
023	O2 Administration Continuous (Nasal/Mask)
024	Vital Signs
032	Set-Up Pulse Oximeter
038	Maintain on Ventilator
049	Start/Change IV Infusion Site
050	Administer IV Fluid
070	Bowel Sounds Assessment
071	Insert NG/OG Tube
073	Perform NG/OG Suction
075	Irrigate NG Tube
079	Catheterization, Foley
082	Measure/Record Intake/Output
086	Clean and Dress Wound
088	Reinforce Dressings
091	Apply Ice/Hot Packs
096	Apply Sling
098	Apply Splint/Immobilize Injury
108	Minor Surgical Procedure (Debride/Suture/Incision)
123	Eye Care (Dressings/Eye Patch)
126	Seizure Care/Precautions
142	Document Appropriate Meds/Treatment
145	Administer Appropriate Medication
A6	Apply Tourniquet
Z014	Endo/Naso-tracheal Intubation
Z027	Cardio Arrest Resuscitation
Z030	Electronic Monitoring of Patient Vital Signs (Propaq)
Z037	Bag Valve Mask Setup
Z039	Perform Ventilation with Bag Valve Mask
Z083	Expose Patient for Exam
Z094	Extremity Traction, Application/Adjust
ZZ03	Needle Thoracostomy
ZZ19	Warm Infusion Fluids
ZZ42	Patient Warming
ZZ58	Rapid Pressure IV Infusion
ZZ65	Conduct Patient Hand-Off

Task	Task Description
ZZ67	Secure Patient to Litter/Airframe
ZZ77	Assess Airway/Breathing
ZZ80	Perform Suction (E-T Tube/Tracheostomy Tube)
ZZ85	Reassess Tourniquet
ZZ93	Manage Seizing Patient
ZZ96	Assemble/Replenish/Resupply Materiel
ZZ98	Preventive Maintenance, Checks, & Services of Equipment

RESULTS

Once the task profiles were completed, the medical supplies needed to perform the tasks were assigned. These task-supply relationships established the clinical requirement for each medical item in the proposed CASEVAC medical supply block. Finally, a patient stream of 16 patients was run against the supply set to yield the final quantities for each supply item. Tables 4 through 6 show the supplies and equipment proposed for the CASEVAC asset.

Table 4: Proposed CASEVAC Consumable Supplies

NSN	NOMEN	CASEVAC QTY	UI	CASEVAC WEIGHT	CASEVAC CUBE	CASEVAC PRICE
6515013215211	Airway Kit Percutaneous Emergency Adult Sterile Disposable	1.00	EA	0.2000	0.0500	\$206.27
6515011676637	Airway Nasopharyngeal Robertazzi 30fr Oblique Tip 12s	3.00	EA	0.7500	0.0500	\$14.80
6515009582232	Airway Pharyngeal Berman Design 80mm Length 12s	2.00	EA	0.0433	0.0043	\$0.53
6510001055807	Bandage Elastic Coban Flesh 3" x 5yd 24s	10.00	EA	2.8917	0.0546	\$30.42
6510000583047	Bandage Gauze Kerlix 4.5ins x 4yds 100s	25.00	EA	0.2875	0.0065	\$24.63
6510002011755	Bandage Muslin Camouflage 37x37x52in 1s	10.00	EA	1.3000	0.0800	\$24.80
6135009857845	Battery Nonrechargeable 1.5v AA 24s (Headlamp/Pulse Ox)	6.00	EA	0.0250	0.0003	\$1.88
6135008264798	Battery Nonrechargeable 1.5v AAA 24s (Otoscope)	6.00	EA	0.0500	0.0005	\$0.81
7210009356665	Blanket Casualty Plas Alum Coated 84x56in Green Taped	4.00	EA	3.0800	0.2800	\$26.32
6515011067648	Canister Assy Suct Surg 1500cc Cap Built-In Fltr Snap-On Lid100s	1.00	EA	0.4340	0.0420	\$1.86
6515004588411	Catheter & Connector Suction Trach 14fr 50s	3.00	EA	0.2130	0.0374	\$5.15
6515013909654	Catheter & Needle Unit Intravenous 18gauge Crs Green Disp Ster 200s	7.00	EA	0.7875	0.0050	\$13.77
6515013909627	Catheter & Needle Unit Intravenous Crs Disp Ster Orange 200s	17.00	EA	0.4845	0.0027	\$40.03
6515001490104	Catheterization Kit Urethral w/Bot-Outlet Drain Bag 16fr Disp	2.00	EA	1.4200	0.5080	\$17.90
53126	Circuit Ventilation, Single Use (Autovent 3000) 10s	2.00	EA	0.0160	0.0200	\$11.80

NSN	NOMEN	CASEVAC QTY	UI	CASEVAC WEIGHT	CASEVAC CUBE	CASEVAC PRICE
6515014661488	Crystalloid and Colloid Pump Cartridges And IV Sets for the Power Infuser. Sterile, Single-Use. 10s	7.00	EA	1.4000	0.1400	\$206.50
6510014575844	Dressing Burn First Aid Water-Gel Type Polyester 8x18 20s	2.00	EA	0.0550	0.0120	\$10.30
6510014081920	Dressing Chest Wound Seal Asherman 10s	2.00	EA	0.3100	0.0024	\$20.14
6510002017425	Dressing First Aid Field Camo 11x12in	3.00	EA	1.5000	0.1140	\$18.87
6510002017430	Dressing First Aid Field Camo 7x8in 1s	4.00	EA	1.1600	0.0680	\$17.72
6510000835573	Dressing First Aid Field White 4x6in Pleated	4.00	EA	0.5600	0.0240	\$10.36
6515011602537	Electrode Electrocardiograph Adhs 30s	6.00	EA	0.1000	0.0180	\$8.18
6515011498841	Gloves Surgeons Gen Surg Sz 7.5 Rubber Prepowdered Ster Disp 50s	4.00	EA	0.3648	0.0380	\$2.11
6515011498842	Gloves Surgeons Gen Surg Sz 8 Rubber Prepowdered Sterile Disp 50s	4.00	EA	0.3648	0.0380	\$2.11
6515011050614	Intravenous Injection Set 12 Components Nonvented Ster Disp 50s	20.00	EA	0.0512	0.0112	\$32.13
8405008893683	Liner Wet Weather Poncho: Polyester Nylon Quilted Camouflage	16.00	EA	8.0000	0.2400	\$519.20
6515008886122	Mask Oronasal Semi-Rigid Translucent Plas Face-Piece w/Conn Semi-Rigid 50s	2.00	EA	0.2200	0.0600	\$2.02
6530014445476	Pad Cooling Chemical 24s	4.00	EA	0.2083	0.0833	\$1.41
65300131711311	Pad Heating Chemical Plastic Chemical	4.00	EA	7.2000	0.0080	\$9.88
6510007863736	Pad Prep Isopropyl Alcohol Impregnated 200s	1.00	EA	0.0025	0.0005	\$0.023
6515014594403	Pads Defibrillation 2-Pack	2.00	EA	6.5000	2.3000	\$88.00
7520009357136	Pen Ball-Point Retractable Med Pt Black 12s	2.00	EA	0.0600	0.0240	\$0.80
6515012045394	Resuscitator Hand Operated Ipp High O2 Small & Med Adult Face Masks W/Case	2.00	EA	2.4000	0.0300	\$366.50
6515012538165	Shield Eye Surg Goffman 50s	2.00	EA	0.0160	0.0004	\$2.14
8520013535671	Skin Cleanser 60pct Alcohol No Rinsing 36s	2.00	EA	0.5000	0.0278	\$2.13
6515012254681	Splint Malleable Alum 36x4.5in 12s	6.00	EA	2.5000	0.2400	\$54.70
6510007219808	Sponge Surg Cotton Gauze 4x4in Sterile 1200s	50.00	EA	0.6667	0.0917	\$2.94
6515014663004	Support Cervical Plas Univ 30s	4.00	EA	0.6500	0.0150	\$363.60
6515014520465	Syringe and Needle Hypodermic Safety 3ml 23gage Ster Disp 100s	2.00	EA	0.0120	0.0140	\$1.64
6515007540412	Syringe Hypodermic Gp 10-12 MI Cap Luer Slip w/o Ndl Concentric Tip 100s	4.00	EA	0.2320	0.0228	\$0.76
6515014570288	Syringe Irrigating 60ml Luer Plas Disp 60s	4.00	EA	0.0833	0.0167	\$6.73
6510009268884	Tape Adhesive Surgical Porous Woven Rayon 3"x10yds 4s	3.00	EA	0.9000	0.0375	\$18.21
6515003830565	Tourniquet Nonpneumatic 42 X 1.5in Lg Camo	2.00	EA	0.4800	0.0400	\$11.82
6515013851697	Tube Drainage Surg Penrose 7/8x12in 200s	2.00	EA	0.0520	0.0140	\$1.50

NSN	NOMEN	CASEVAC QTY	UI	CASEVAC WEIGHT	CASEVAC CUBE	CASEVAC PRICE
6515010369034	Tube Endotracheal Murphy 7.5mm 10s	2.00	EA	0.2400	0.0520	\$4.59
6515001050759	Tube Endotracheal Murphy 8.0mm OD 10s	2.00	EA	0.2000	0.0100	\$5.58
6515001490316	Tube Stomach Surgical Plastic Salem E19 w/Funnel 16fr Dbl Lumen 48" Lg 50s	4.00	EA	0.3200	0.0560	\$14.74
0102LF0135500	Us Field Medical Card Form DD 1380 100s	1.00	EA	0.5000	0.0120	\$2.06
6510014999285	Wound Pack Hemostatic Treatment 5x7" Pkg No Refrigeration Req'd	2.00	EA	0.1600	0.1200	\$19.70
6515015096866	Sling, Pelvic Fracture Stabilizer	1.00	EA	0.0000	0.0000	\$50.00
CATEGORY TOTALS						
Cost	\$2,300.17					
Weight	49.9511					
Cube	5.1225					

* The Pelvic Sling is a new replacement for the MAST trouser. Weight and cube are yet to be determined.

Table 5: Proposed CASEVAC Equipment

NSN	NOMEN	CASEVAC QTY	UI	CASEVAC WEIGHT	CASEVAC CUBE	CASEVAC PRICE
6530014940126	Basin Emesis Plas Kidney Shape 500cc	2.00	EA	1.1000	0.2400	\$13.90
6515013637700	Board Spinal Folding Heavy Gauge Alum Folded Size 18.50x36x2.75", 0.5000,	2.00	EA	20.0000	6.0000	\$502.88
6515014794272	Defib-Monitor Auto External w/Override	1.00	EA	5.2000	0.2800	\$3,490.00
6515013448487	Injector Tube Reusable 1ml & 2ml Ndl Units	2.00	EA	0.2200	0.1300	\$8.68
6515014553888	Lantern Electric Head Mount Halogen/Krypton	2.00	EA	1.1000	0.2400	\$46.00
6515014509790	Laryngoscope Set Ent Pocket Black Waterproof Light Green Sys	2.00	EA	1.0000	0.6000	\$107.00
6540014553885	Lens Cover Red Lantern Electric Head Mount	2.00	EA	1.0000	0.6000	\$107.00
6530014325114	Litter Rigid Folding Raven Polypropylene	16.00	EA	176.0000	0.3200	\$4,080.00
6515014322711	Monitor Vital Signs Propaq Nibp/Spo2/EKG	2.00	EA	50.0000	4.8000	\$42,555.60
6545014586057	Otoscope & Ophthalmoscope Set Basic Soft	2.00	SE	1.1000	0.2400	\$178.00
6515014189022	Oximeter Pulse Hand-Held Battery Powered (Non-Rechargeable)	2.00	EA	1.2500	0.0200	\$1,358.00
6515014995112	Pump Intravenous Infusion Mini Rapid IV (Power Infuser M100b-3a)	2.00	EA	0.9800	0.7200	\$3,610.96
6530014572239	Regulator Oxygen Gas Admin Lsp Rhino	3.00	EA	4.5000	1.5000	\$567.60
6515012045394	Resuscitator Hand Operated IPP High O2 Small & Med Adult Face Masks W/Case	2.00	EA	2.4000	0.0300	\$366.50
6515009357138	Scissors Bandage 7.25	2.00	EA	0.3800	0.0280	\$12.60
6515010394884	Sphygmomanometer Aneroid 300mm Max Calibration w/Clip For Cuff	2.00	EA	2.5000	0.2000	\$24.82

NSN	NOMEN	CASEVAC QTY	UI	CASEVAC WEIGHT	CASEVAC CUBE	CASEVAC PRICE
6515012508936	Splint Traction-Extraction Adult Aluminum	2.00	EA	3.0000	0.2080	\$1,159.34
6515013146694	Stethoscope Littman Classic Ili 28in Lg	2.00	EA	2.0000	0.0060	\$98.82
6515014350050	Suction Apparatus Surgical Portable	1.00	EA	5.0000	0.5000	\$2,673.24
6545009577650	Surgical Instrument Set Minor Surgery	1.00	SE	1.8700	0.1330	\$275.75
6515013737292	Thermometer Clinical Human Oral Digital	1.00	EA	0.0100	0.0010	\$9.50
6515014512320	Ventilator Volume Portable Auto Control Module Patient Valve (Autovent 3000)	2.00	EA	12.0000	12.4768	\$4,996.34
CATEGORY TOTALS						
Cost	\$66,242.53					
Weight	292.6100					
Cube	29.2728					

Table 6: Proposed CASEVAC Medications

NSN	NOMEN	CASEVAC QTY	UI	CASEVAC WEIGHT	CASEVAC CUBE	CASEVAC PRICE
6505011169245	Albuterol Inhalation 17gm Cont 200 Sprays	2.00	PG	0.2600	0.0180	\$36.72
6505001009985	Aspirin Tablets USP 0.324gm 100s	1.00	BT	0.1400	0.0100	\$1.49
6505010946196	Atropine Sulfate Injection USP 0.1mg/cc 10ml Bottle 10s	0.20	BX	0.2800	0.0240	\$7.10
6505015053476	Diazepam Inj 5mg/ml 2 ml Cartridge Unit 10s	0.20	PG	0.1100	0.0240	\$4.71
6505001487177	Diphenhydramine Hcl Inj 50mg/ml 1ml Syr 10s	0.20	BX	0.0500	0.0066	\$2.56
6505010932384	Epinephrine Inj 0.1mg/ml Syr/Ndl 10ml 10s	0.20	PG	0.3200	0.0280	\$3.97
6505007341026	Epinephrine Inj USP 1mg/ml 1ml Ampul 10s	0.20	PG	0.0500	0.0024	\$1.13
6505012811247	Hetastarch In Sodium Chloride Injection 500ml Bag 12 Bags/Pg	0.17	PG	2.6667	0.0833	\$49.19
6505012149062	Ibuprofen Tablets USP 800mg 500 Tablets Per Bottle	1.00	BT	1.4700	1.4700	\$14.12
6505011947265	Lidocaine Hcl 0.4% & D5W Inj 500ml Bag 18s	0.06	PG	1.3611	0.0483	\$7.23
6505015033316	Lidocaine Hydrochloride Injection USP 5ml Unit 10 Per Package	0.10	PG	0.0550	0.0120	\$7.18
6505005843131	Lidocaine Hydrochloride Jelly USP 2% 30ml 30s	0.30	PG	0.0050	0.0002	\$0.25
6505012444736	Midazolam Hcl Inj 5mg/ml 1ml Vial 10s	0.20	PG	0.0360	0.0016	\$12.60
6505013025530	Morphine Sulfate Injection USP 10mg Automatic Injector	15.00	EA	0.4500	0.0450	\$117.30
6505000797867	Naloxone Hydrochloride Injection 0.4mg/ml 1ml Ampul 10s	0.10	BX	0.0120	0.0050	\$0.49
6505012463781	Nitroglycerin Lingual Aerosol 14.49gm Container	1.00	CO	0.0800	0.0029	\$34.79
6505001325181	Oxygen USP 99% Cylinder Type D 95gl	2.00	EA	26.0000	0.6000	\$281.40
6505014623025	Ringer's Injection Lactated USP 1000ml Bag 12 Bags Per Package	0.83	PG	0.2083	0.0100	\$7.21

NSN	NOMEN	CASEVAC QTY	UI	CASEVAC WEIGHT	CASEVAC CUBE	CASEVAC PRICE
6505014622436	Sodium Chloride Injection USP 1000ml Bag 12s	0.50	PG	0.2750	0.0600	\$4.22
CATEGORY TOTALS						
Cost		\$593.66				
Weight		33.8291				
Cube		2.4514				

The amount of supplies indicated would be for a full load-out mission in which the maximum number of patients (16) may be encountered, such as accompanying a deep penetration raid with an MEU (SOC). However, the actual amount of supplies carried aboard the CASEVAC aircraft is expected to vary according to mission requirements. A CASEVAC mission to pick up 2 wounded Marines, for instance, would not require CASEVAC corpsmen to load all 16 litters and 4 spine boards. Equipment choices, such as the vitals monitor, Autovent ventilator, and infusion pump, also allow for two litter positions to be set up as critical care beds.

DISCUSSION AND CONCLUSIONS

Aeromedical Considerations

Special consideration has to be given to choosing medical equipment for use in aircraft. Heavy vibration, noise, and changing atmospheric pressure can adversely affect some medical equipment and tasks.⁶⁻⁸ In addition, some electronic equipment can interfere with aircraft avionics, creating a safety hazard. In choosing equipment for CASEVAC aircraft, careful consideration was given to selecting items that were air transport certified.

For instance, not all automated external defibrillators (AED) can be used in aircraft. However, the Heartstream Forerunner series of AEDs is approved for use aboard both commercial and U.S. Air Force aircraft. In particular, the Heartstream FR2 AED (NSN 6515-01-479-4272) recommended by this study has been approved for use aboard rotary aircraft.^{9, 10}

The Propaq 206 Encore vital signs patient monitor (NSN 6515-01-432-2711) recommended in this study also received an Air Force airworthiness rating after extensive testing, and is authorized for use aboard all Air Force aircraft.¹¹

Cramped aircraft fuselages make gravity drainage of intravenous (IV) bags unreliable. Pressure changes at different altitudes also make air-bladder IV infusers unreliable. Therefore, electronic infuser pumps are recommended for aeromedical transport.⁶ The Power Infuser M100B-3A (NSN 6515-0-149-95112) recommended in this study was specifically designed for administering crystalloid and colloid fluids in medical evacuation helicopters, and was granted fleetwide airworthiness certification by the U.S. Army in 2002.¹²

Pressure changes at altitude also affect the use of inflatable Military Antishock Trousers (MAST), commonly used in the military for stabilization of pelvic fractures. Therefore, this study recommends replacing MAST with the new Pelvic Sling (NSN 6515-01-509-6866),

recently introduced to the nation's military stocks. The Pelvic Sling has been shown in studies sponsored by the Office of Naval Research to effectively stabilize pelvic ring fractures, and is easier and quicker to apply than MAST. The device is also significantly smaller and lighter than MAST, saving a significant amount of weight and cubic volume.¹³

Many of the casualties encountered by CASEVAC crews will require ventilation en route. While bag mask resuscitators can be utilized in the short term, long duration flights will require some form of automatic ventilator. The logistics and training tail of portable ventilators makes their use for CASEVAC impractical. However, several gas and/or battery-powered automatic resuscitators on the market are designed to be used by rescue teams with basic life support-level skills. The Autovent 3000 (NSN 6515-01-451-2320) is already used by Navy corpsmen and has widespread use in civilian and military aeromedical transport services, including Navy aeromedical transport.¹⁴ It can also be adapted for use with an in-line volumetric spirometer, manometer, and capnograph to assure proper ventilations at a glance, an important consideration in an aircraft where vibration and poor lighting can make verifying proper chest rise difficult.¹⁵

This study recognizes the danger inherent with carrying compressed oxygen aboard aircraft operating in combat environments. An oxygen tank struck by a bullet or shrapnel can turn into a deadly missile or bomb. However, severely injured persons with hemorrhage-induced perfusion deficit are at great risk of hypoxia in flight.^{6, 8} Therefore, this study included oxygen tanks and related apparatus in its proposed equipment list for use at the discretion of the aircraft commander. At some future date, if the Marine Corps incorporates dedicated CASEVAC aircraft into its aircraft wings, consideration should be given to installing oxygen generators in the patient compartments similar to those installed in the Army's new UH-60Q MEDEVAC helicopter.

Flight Crew Considerations

The composition of medical flight crews varies throughout the medical response field. In civilian emergency medical services, air ambulances are usually staffed by a 2-person crew composed of a flight nurse experienced in emergency and critical care, and one of the following: a flight surgeon, another flight nurse, a respiratory therapist, or a critical care paramedic. No studies have been made on whether one crew composition provides better medical outcomes than another.¹⁶ In all cases, however, the medical personnel are flight certified.

Unlike the Marine Corps, the Army's larger number of air assets allows it to maintain dedicated combat CASEVAC aircraft. These are usually a variant of the UH-60 Blackhawk manned by a crew of 4 — 2 pilots, a crew chief, and a 91W medic. The skill level of the medic varies, with a minimal standard of basic emergency medical technician level with some additional medical skill sets, though many senior Army flight medics obtain paramedic-level certification. All are flight crew certified.¹⁷

The CASEVAC variant of the UH-60 is capable of carrying 6 litter patients. The larger carrying capacities of the Marine Corps Osprey, Sea Knight, and Sea Stallion aircraft could overwhelm a single corpsman caring for as many as 16 wounded Marines. This suggests a minimum 2-person medical flight crew would be required for any long-range Marine Corps CASEVAC asset.

The skill levels identified by this study indicate the need for medical technicians with advanced life support and critical care skills. This corresponds with the findings of similar studies into CASEVAC. During the Yom Kippur War in 1973, more than 50% of all Israeli aeromedical patients had cardiac and/or respiratory complications. During the Lebanon War in the 1980s, 92% of Israeli casualties evacuated by aeromedical aircraft required cardiac monitoring, 61% required artificial respirations, and five percent required defibrillation. During Operation Desert Storm, the British military felt advanced life support and trauma skills were essential for flight medics.¹⁷

Several types of Navy medical personnel have the training to perform a large number of the clinical tasks identified by this study, and can be trained to perform the remaining tasks with competence. However, only one of these already possesses a substantial degree of the required medical skills along with flight-crew training and certification – the search and rescue medical technician (HM-8401), also known as the SAR corpsman.^{14, 18} Senior SAR corpsmen acquire paramedic-level medical skills; however, additional training will be necessary to fill remaining skills deficits. As part of their career training, SAR corpsmen also attend Field Medical Service School and survival, evasion, and recovery training, thus acquiring combat, survival, and field craft skills useful in hostile territory.¹⁸ Therefore, a combat casualty transport team of 2 advanced-level SAR corpsman is recommended for this CASEVAC asset.

Equipment Transportation Considerations

The amount of equipment recommended by this study weighs 376 pounds and fills nearly 37 cubic feet. Placing it aboard a dedicated CASEVAC aircraft would be of little concern, but loading and off-loading this amount from a “lift of opportunity” aircraft could consume valuable time and manpower. Configuring the supplies aboard an aircraft cargo pallet(s) could reduce loading and offloading time and manpower requirements. Maryland-based ARINC Engineering Services LLC produces the ARINC Aeromedical Pallet System (AAPS) based on the 463L standard aircraft cargo pallet that is designed to quickly convert any cargo airplane or any helicopter using the Helicopter Internal Cargo Handling System into a medical evacuation aircraft in about 20 minutes. The AAPS pallets come in 4 configurations, including 2 bearing stacked litters.¹⁹ Consideration should be given to evaluating the AAPS or any other similar system for possible use in Marine Corps CASEVAC aircraft.

REFERENCES

1. Clark V. Sea Power 21. *Naval Institute Proceedings*. 2002 (October 2002).
2. Miller C, Lt., USN. Universal Needs Statement (UNS) Long Range Raid CASEVAC. *Originator's Request, Rev. 1-01*. Quantico, VA: Marine Corps Combat Development Command; 2000.
3. Semple GJ, LCdr. Request for Approval of Proposed Equipment, Medicine and Consumable Supply Lists for 22d MEU Combat Casualty Transport Teams. In: Surgeon IM, ed; 2002.
4. Tactical Combat Casualty Care: Prehospital Care in the Tactical Environment: The Committee on Tactical Combat Casualty Care; 2003 (Draft):52.
5. Galarneau MR, Pang G, Konoske PJ, Tropeano A. *Marine Corps En Route Care System (ERCS): Development of Patient Treatment and Supply Requirements*. San Diego: Naval Health Research Center; 2002. TR No. 02-24.
6. Martin TE. *Handbook of Patient Transport*. London: Greenwich Medical Media Ltd.; 2001.
7. Hardaway RM. *Care of the Wounded in Vietnam*. Manhattan, Kansas: Sunflower University Press; 1988.
8. Case RB. Preevacuation and Evacuation Planning: Aeromedical Evacuation. In: Frederick M. Burlke J, ed. *Disaster Medicine: Application for the Immediate Management and Triage of Civilian and Military Disaster Victims*. New York: Medical Examination Publishing Co., Inc.; 1984:373.
9. HP Receives United States Air Force Approval for Lifesaving Heartstream Forerunner AED. *MERGINET* [Electronic EMS Newsletter]. Available at: www.merginet.com/tgp/1998/9810/htst-usaf.shtml, 2003.
10. *Heartstream AEDs Technical Reference Manual*: Philips Medical Systems; 2002.
11. Sylvester J, Hade EW. *Testing and Evaluation of the Protocol Systems, Inc., Propaq 206 El Encore Vital Signs Patient Monitor*. Brooks AFB, TX: Air Force Research Laboratory, Human Effectiveness Directorate, Flight Stress Protection Division, Systems Research Branch; July 1998 1998. AFRL-HE-TR-1998-0053.
12. U.S. Army Gives Power Infuser an Airworthy Rating. *Walter Reed Army Institute of Research* [Internet]. Available at: www.wrair.army.mil/news&events/infuser.htm. Accessed June 3, 2003, 2003.

13. Bottlang M, Krieg J, Mohr M, Simpson T, Madey S. Emergent Management of Pelvic Ring Fractures with Use of Circumferential Compress. *The Journal of Bone and Joint Surgery*. 2002 2002;84-A(Supplement 2).
14. Horrall ML. United States Navy SAR Medical Technician Emergency Treatment Protocols. NAS Jacksonville, FL: U.S. Navy; 1995:104.
15. Rola P. Air Transport and Ventilators: A Review. *McGill University Health Center*. Available at: <http://sprojects.mmi.mcgill.ca/heart/pages/man000104rl.html>. Accessed May 19, 2003, 2003.
16. Stephen Thomas. Aeromedical Transport. *Disaster and Trauma eBook*. Omaha, Neb.: eMedicine.com Inc.; 2001.
17. DeLorenzo R, Maj. Military and Civilian Emergency Aeromedical Services: Common Goals and Different Approaches. *U.S. Army Medical Department Journal* [Internet]. Available at: <http://das.cs.amedd.army.mil/journal/j9733.htm>. Accessed June 24, 2003, 2003.
18. Parodi VA, Konoske PJ, Galarneau MR, Tropeano A. Marine Corps En Route Care System: Development of Personnel and Training Requirements: Naval Health Research Center; 2002:26.
19. Fehrle B. Aeromedical Evacuation. *Military Medical Technology*. March 2003 2003;7(2):5-7.

APPENDIX A

CASEVAC PATIENT CONDITIONS

CASEVAC Patient Conditions
Based on JRCAB Patient Conditions

PC	PC Description
001	Cerebral concussion closed with/without nondepressed linear skull fracture severe — loss of consciousness from 2 to 12 hours
002	Cerebral concussion closed with/without nondepressed linear skull fracture moderate — loss of consciousness less than 2 hours
003	Cerebral contusion closed with/without nondepressed linear skull fracture severe — loss of consciousness greater than 24 hours with focal neurological deficit
004	Cerebral contusion closed with/without nondepressed linear skull fracture moderate — loss of consciousness from 12-24 hours without focal neurological deficit
005	Cerebral contusion closed with intracranial hematoma with/without non-depressed linear skull fracture — severe — large hematoma (including epidural hematoma) with rapidly deteriorating comatose patient
006	Cerebral contusion closed with nondepressed linear skull fracture severe — loss of consciousness greater than 24 hours with/without focal neurological deficit
007	Cerebral contusion closed with depressed skull fracture severe — with associated intracerebral hematoma and/or massive depression
008	Cerebral contusion closed with depressed skull fracture moderate — no associated hematoma or significant effect from depression
009	Cerebral contusion with open skull fracture severe — with intracranial fragments and/or depressed skull fracture; eyelid and eyeball laceration with retained intraocular foreign body
010	Cerebral contusion with open skull fracture moderate — without intracranial fragments and/or depressed skull fracture
011	Intracranial hemorrhage spontaneous nontraumatic all cases
013	Wound scalp open without cerebral injury or skull fracture severe — scalped with avulsion of tissue
014	Wound scalp open without cerebral injury or skull fracture moderate — scalp laceration
015	Fracture facial bones closed exclusive of mandible severe — multiple fractures
016	Fracture facial bones closed exclusive of mandible moderate — single fracture
017	Wound face jaws and neck open lacerated with associated fractures excluding spinal fractures severe — with airway obstruction

PC	PC Description
018	Wound face jaws and neck open lacerated with associated fractures excluding spinal fractures moderate — without airway obstruction; eyelid and eyeball laceration with retained intraocular foreign body
019	Wound face and neck open lacerated contused without fractures severe — with airway obstructions and/or major vessel involvement
020	Wound face and neck open lacerated contused without fractures moderate — without airway obstruction or major vessel involvement
021	Eye wound severe — loss of intraocular fluid with/without retinal detachment, with severe lid laceration, eye not salvageable.
022	Eye wound lacerated moderate — without retinal detachment or retinal injury no foreign body retained without loss of vitreous fluid patient has hyphema eye salvageable
023	Hearing impairment severe
025	Fracture spine closed without cord damage unstable lesion
026	Fracture spine closed without cord damage stable lesion
027	Fracture spine closed with cord damage cervical spine with respiratory involvement
028	Fracture spine closed with cord damage below cervical spine (progressive)
029	Fracture spine open with cord damage cervical spine with respiratory distress
030	Fracture spine open with cord damage below cervical spine (progressive)
033	Strains and sprains sacroiliac region severe — non-ambulatory
037	Burn thermal partial thickness head and neck greater than 5% but less than 10% of total body area and/or eye involvement
039	Burn thermal full thickness head and neck greater than 5% but less than 10% of total body area with eye involvement
040	Burn thermal full thickness head and neck less than 5% of total body area and no eye involvement
041	Fracture clavicle closed all cases
042	Wound shoulder girdle open with bone injury severe — joint involvement
043	Wound shoulder girdle open with bone injury moderate — no joint involvement

PC	PC Description
044	Fracture humerus closed upper shaft all cases
045	Wound upper arm open penetrating lacerated without fracture severe — with nerve and/or vascular injury
046	Wound upper arm open penetrating lacerated without fracture moderate — without nerve or vascular injury
047	Wound upper arm open with fractures and nerve and vascular injury arm non-salvageable
048	Wound upper arm open with fractures and nerve injury no vascular injury arm salvageable
049	Fracture radius and ulna closed severe — shafts of bones
050	Fracture radius and ulna closed moderate — Colles Fracture
051	Wound forearm open lacerated penetrating without bone nerve or vascular injury with major loss of muscle tissue severe — requiring major debridement
052	Wound forearm open lacerated penetrating without bone nerve or vascular injury moderate — not requiring major debridement
053	Wound forearm open lacerated penetrating with fracture and with nerve and vascular injury forearm not salvageable
054	Wound forearm open lacerated penetrating with fracture and with nerve and vascular injury forearm salvageable
055	Fracture hand or fingers closed severe — requiring open reduction
056	Fracture hand and/or fingers closed moderate — not requiring closed reduction
057	Wound hand and/or fingers open lacerated without fractures severe — superficial and deep tendon involvement
058	Wound hand and/or fingers open lacerated without fractures moderate — no tendon involvement or limited to sublimis tendon involvement
059	Wound hand open lacerated contused crushed with fracture(s) all cases — involving fractures of carpals and/or metacarpals
060	Wound fingers open lacerated contused crushed with fracture(s) of phalangeals requiring rehabilitation
061	Crush injury upper extremity severe — limb not salvageable
062	Crush injury upper extremity moderate — limb salvageable

PC	PC Description
064	Dislocation shoulder closed all cases
065	Dislocation/fracture elbow closed acute all cases
067	Dislocation hand or wrist closed acute
069	Amputation hand traumatic complete all cases
070	Amputation forearm traumatic complete all cases
071	Amputation full arm traumatic complete all cases
077	Burn thermal partial thickness upper extremities greater than 10% but less than 20% of total body area involved
078	Burn thermal partial thickness upper extremity less than 10% of total body area involved
079	Burn thermal full thickness upper extremities greater than 10% but less than 20% of total body area involved
080	Burn thermal full thickness upper extremity less than 10% of total body area involved
081	Fracture ribs closed severe — multiple fractures
082	Fracture rib(s) closed moderate
083	Injury lung closed (blast crush) with pneumohemothorax severe — one lung with pulmonary contusion and acute severe respiratory distress
084	Injury lung closed (blast crush) with pneumohemothorax moderate — one lung with pulmonary contusion and respiratory distress
085	Wound thorax (anterior or posterior) open superficial lacerated contused abraded avulsed requiring major debridement
086	Wound thorax (anterior or posterior) open superficial lacerated contused abraded avulsed not requiring major debridement
087	Wound thorax (anterior or posterior) open penetrating with associated rib fractures and pneumohemothorax acute severe respiratory distress
088	Wound thorax (anterior or posterior) open penetrating with associated rib fractures and pneumohemothorax moderate respiratory distress
092	Burn thermal partial thickness trunk greater than 20% but less than 30% of total body area involved

PC	PC Description
094	Burn thermal full thickness trunk greater than 20% but less than 30% of total body area involved
095	Burn thermal full thickness trunk greater than 10% but less than 20% of total body area involved
096	Wound abdominal wall (anterior or posterior) lacerated abraded contused avulsed without entering abdominal cavity severe — requiring major debridement
097	Wound abdominal wall (anterior or posterior) lacerated abraded contused avulsed without entering abdominal cavity not requiring major debridement
098	Wound liver closed acute (crush fracture) major liver damage
099	Wound liver closed acute (crush fracture) minor liver damage
100	Wound spleen closed acute (crush fracture) all cases
101	Wound abdominal cavity open with lacerating penetrating perforating wound to the large bowel
102	Wound abdominal cavity open with lacerating penetrating perforating wound to small bowel without major or multiple resections
103	Wound abdominal cavity open with penetrating perforating wound of liver major damage
104	Wound abdominal cavity open with penetrating perforating abdominal wound with lacerated liver
105	Wound abdominal cavity open with penetrating perforating wound of spleen
106	Wound abdominal cavity open with lacerated penetrated perforated wound with shattered kidney
108	Wound abdominal cavity open with lacerated penetrating perforating wound with shattered bladder
109	Wound abdominal cavity open with lacerated penetrating perforating wound with lacerated bladder
110	Wound buttocks severe — open lacerated penetrating perforating and avulsed
111	Wound buttocks moderate — open lacerated contused and abraded
112	Displaced fracture of pelvis closed with associated soft tissue damage and pelvic organ damage
113	Non-displaced fracture of pelvis closed with associated soft tissue damage

PC	PC Description
114	Wound abdomen open with pelvic fracture and penetrating perforating wounds to multiple pelvic structures (male or female)
115	Wound abdomen open with pelvic fracture and penetrating perforating wounds to pelvic colon only (male or female)
116	Wound external genitalia male severe — lacerated avulsed crushed
118	Wound external genitalia female severe — lacerated avulsed crushed
120	Fracture closed femur shaft all cases
121	Wound thigh open without fracture nerve or vascular injury requiring major debridement
122	Wound thigh open without fracture nerve or vascular injury not requiring major debridement
123	Wound thigh open lacerated penetrating perforating with fracture and nerve/vascular injury limb not salvageable
124	Wound thigh open lacerated penetrating perforating with fracture and nerve and/or vascular injury limb salvageable
125	Wound knee open lacerated penetrating perforating with joint space penetration shattered knee
126	Wound knee open lacerated penetrating perforating with joint space penetration articular cartilage damage no bone injury
127	Fracture closed tibia and fibula shaft all cases
128	Wound lower leg open lacerated penetrating perforating without fractures requiring major debridement
129	Wound lower leg open lacerated penetrating perforating without fractures not requiring major debridement
130	Wound lower leg open lacerated penetrating perforating with fracture and nerve/vascular injury limb not salvageable
131	Wound lower leg open lacerated penetrating perforating with fracture and nerve and/or vascular injury limb salvageable
132	Fracture ankle/foot closed displaced requiring reduction
133	Fracture ankle/foot closed nondisplaced not requiring reduction
134	Wound ankle foot toes open lacerated contused without fractures but requiring major debridement

PC	PC Description
135	Wound ankle foot toes open lacerated contused without fractures not requiring major debridement
136	Wound ankle foot toes open penetrating perforating with fractures and nerve/vascular injury limb not salvageable
137	Wound ankle foot toes open penetrating perforating with fractures and nerve and/or vascular injury limb salvageable
138	Crush injury lower extremity limb not salvageable
139	Crush injury lower extremity limb salvageable
140	Dislocation hip closed acute all cases
141	Tear ligaments knee acute complete rupture
142	Tear ligaments knee acute incomplete rupture
144	Amputation foot traumatic complete all cases
145	Amputation below knee traumatic complete all cases
146	Amputation traumatic complete requiring hip disarticulation
147	Amputation above knee traumatic complete
148	Sprain ankle closed acute with complete ligament rupture
152	Burn thermal partial thickness lower extremities and genitalia greater than 30% but less than 40% of total body area involved
153	Burn thermal partial thickness lower extremity and genitalia greater than 15% but less than 30% of total body area involved
154	Burn thermal full thickness lower extremities and genitalia greater than 30% but less than 40% of total body area involved
155	Burn thermal full thickness lower extremity and genitalia greater than 15% but less than 30% of total body area involved
157	Insect bites and stings (unspecified body area) with systemic symptoms and/or respiratory difficulty
159	Multi-injury wound (MIW) brain and chest with sucking chest wound and pneumothorax

PC	PC Description
160	MIW brain and abdomen with penetrating perforating wound colon
161	MIW brain and abdomen with penetrating perforating wound kidney
162	MIW brain and abdomen with penetrating perforating wound bladder
163	MIW brain and abdomen with shock and penetrating perforating wound spleen
164	MIW brain and abdomen with shock and penetrating perforating wound liver
165	MIW brain and lower limbs requiring bilateral above knee amputations
166	MIW chest with pneumohemothorax and abdomen with penetrating wound colon
167	MIW chest with pneumohemothorax and abdomen with penetrating perforating wound kidney
168	MIW chest with pneumohemothorax and abdomen with perforating wound bladder
169	MIW chest with pneumohemothorax and abdomen with penetrating perforating wound spleen
170	MIW chest with pneumohemothorax and abdomen with penetrating perforating wound liver
171	MIW chest with pneumohemothorax and limbs with fracture and vascular injury
172	MIW abdomen with penetrating perforating wound of colon and bladder
173	MIW abdomen with penetrating perforating wound of colon and spleen
174	MIW abdomen with penetrating perforating wound of colon and liver
175	MIW abdomen and limbs with penetrating perforating wound of colon and open fracture and neurovascular injury of salvageable lower limb
176	MIW abdomen and pelvis with penetrating perforating wound of liver and kidney
177	MIW abdomen and pelvis with penetrating perforating wounds of spleen and bladder
178	MIW abdomen pelvis limbs with fracture and neurovascular injury limb salvageable and penetrating wound kidney

PC	PC Description
179	MIW abdomen pelvis limbs without fracture or neurovascular injury and penetrating perforating wound bladder
180	MIW abdomen and lower limbs with fracture and nerve injury with penetrating wound of spleen with full thickness burns to greater than 20% of TBSA
181	MIW abdomen and limbs without fracture or nerve injury with penetrating wound of liver
182	MIW chest with pneumohemothorax soft tissue injury to upper limbs and penetrating wound of brain
183	MIW chest with pneumohemothorax soft tissue injury to upper limbs and abdomen with wound of colon
184	MIW chest with pneumohemothorax pelvis and abdomen with wound of colon and bladder
185	MIW abdomen and chest with multiple organ damage
186	Multiple nonperforating fragment wounds of skin and soft tissue
187	Trench foot immersion foot severe — vesicle formation
188	Trench foot immersion foot moderate — no vesicle formation
190	Frostbite full skin thickness or deeper involvement
191	Frostbite less than full skin thickness
192	Hypothermia all cases
193	Heat stroke
196	Appendicitis acute with perforation rupture peritonitis
197	Appendicitis acute without perforation rupture peritonitis
198	Inguinal hernia complicated direct or indirect sliding incarceration of bowel
224	Corneal abrasion
235	Asthma with disabling symptoms or repeated attacks

PC	PC Description
236	Asthma other cases
245	Diarrheal disease severe
249	Peptic ulcer gastric or duodenal penetrating and/or perforating
259	Ischemic heart disease
263	Meningo-encephalitis uncomplicated
264	Meningo-encephalitis complicated
265	Near drowning without cervical spine injury or hypothermia all cases
266	Toxic inhalation including burn — related respiratory injuries severe — all cases
268	White phosphorus burns resultant partial thickness burns < 40% TBSA all cases
277	Renal/ureteral calculus causing obstruction impacted
278	Renal/ureteral calculus not causing obstruction
279	Epididymitis, cystitis, prostatitis, orchitis, including testicular torsion, all cases
304	Stress reaction severe unstable slow improvement
305	Stress reaction severe stable slow improvement
311	Eye wound lacerated penetrated with retinal injury eye salvageable
312	Wound knee open lacerated penetrating perforating with joint space penetration no bone or articular cartilage injury
313	Wound abdominal cavity open with lacerated penetrating perforating wound kidney moderate — kidney salvageable
314	Stress reaction severe unstable delayed improvement
315	Stress reaction severe unstable persisting

PC	PC Description
319	Wound fingers open lacerated contused crushed with fracture(s) of phalangeals not requiring rehabilitation
322	Fracture mandible with/without oral laceration without airway involvement unstable severe requiring open reduction
323	Fracture mandible with/without oral laceration without airway involvement mild displacement stable
324	Stress reaction severe stable — delayed improvement
325	Stress reaction severe stable persisting
331	Malaria severe — all species
332	Malaria moderate — all species
335	Snake bite
346	Eye wound directed energy induced (laser) severe of macula and/or optic nerve, with vitreous blood, severe visual loss, one or both eyes.
347	Eye wound directed energy induced (laser/RFR) moderate to severe, posterior, nonmacular, nonoptic nerve, and visual loss secondary to vitreous blood.
349	Eye wound directed energy induced (laser/RFR) mild to moderate, anterior, pain with photophobia and disruption of corneal integrity.
350	Eye wound directed energy induced (laser/RFR) mild flash blindness no permanent injury

APPENDIX B

CASEVAC GENERIC PATIENT TYPES

CASEVAC Generic Patient Types With Linked JRCAB Patient Codes

Trauma Conditions

CLOSED HEAD WOUND	OPEN HEAD WOUND/ SIMPLE	OPEN HEAD WOUND/ PENETRATION OF BRAIN	FACE & THROAT INJURIES	EYE INJURIES
001	013	009	015	021
002	014	010	016	022
003		159	017	224
004		160	018	311
005		161	019	346
006		162	020	347
007		163	322	349
008		164	323	350
011		165		
023		182		

OPEN/ PENETRATING WOUNDS	WOUNDS WITH EXTREMITY FRACTURES	CLOSED FRACTURES/ DISLOCATIONS	CLOSED FRACTURES/ PELVIC	SPINAL INJURIES
045	042	041	112	025
046	043	044	113	026
051	047	049		027
052	048	050		028
057	053	055		029
058	054	056		030
110	059	064		033
111	060	065		
121	061	067		
122	062	081		
128	123	082		
129	124	120		
134	125	127		
135	126	132		
186	130	133		
	131	138		
	136	139		
	137	140		
	312	141		
	319	142		
		148		

CHEST WOUND	CHEST & ABDOMEN WOUNDS W/ PNEUMO- THORAX	CHEST & ABDOMINAL WOUNDS	ABDOMINAL OR GENITALIA WOUND	ABDOMINAL WOUND W/ FRACTURE
085	083	185	096	175
086	084		097	178
	087		101	180
	088		102	
	166		103	
	167		104	
	168		105	
	169		106	
	170		108	
	171		109	
	183		116	
	184		118	
			172	
			173	
			174	
			176	
			177	
			179	
			181	
			313	

ABDOMINAL WOUND W/ PELVIC FRACTURE	ABDOMINAL CRUSH INJURIES	AMPUTATIONS	MAJOR BURNS	TOXIC INHALATION
114	098	069	037	266
115	099	070	039	
	100	071	040	
		144	077	
		145	078	
		146	079	
		147	080	
			092	
			094	
			095	
			152	
			153	
			154	
			155	
			268	

Environmental Injuries

ENVIRONMENTAL INJURIES: COLD INJURIES	ENVIRONMENTAL INJURIES: HYPOTHERMIA	ENVIRONMENTAL INJURIES: HEAT INJURIES	ENVIRONMENTAL INJURIES: NEAR DROWNING	ENVIRONMENTAL INJURIES: SNAKE BITE	ENVIRONMENTAL INJURIES: INSECT BITE (ANAPHYLAXIS)
187	192	193	265	335	157
188					
190					
191					

Illness

ACUTE ABDOMEN	REGIONAL DISEASES	COMBAT STRESS	RESPIRATORY DISEASE	ISCHEMIC CHEST PAIN
196	245	304	235	259
197	331	305	236	
198	332	314		
249	263	315		
277	264	324		
278		325		
279				

Appendix C

CASEVAC Treatment Briefs

CASEVAC Treatment Profiles

SPINAL INJURIES

Patient presents with closed or open injury to the spine, with back or neck pain. Forty-five percent will present with weakness or paralysis of the limbs, and mild to moderate respiratory distress. Pulse and blood pressure remain stable in most, though 15% may experience tachycardia. All will have cervical collars applied; all should be secured to spine boards as soon as possible. Thirty% will require airways, including intubation and ventilation with oxygen. Fifteen% will require a cricothyroidotomy to secure the airway. IVs will be required in 45% and nasogastric intubation in 30%. Foley catheterization needed in 75%. Reinforce dressings as needed. Seventy-five% will require pain medications.

CLOSED HEAD INJURY

Patient presents with cerebral concussion, closed, with or without skull fracture or intracranial hematoma and unconsciousness of up to 24 hours (90%). Blood pressure remains stable in 70%; the remainder will be hypertensive with bradycardia and shallow or irregular breathing. Sixty% respond only to pain, 20% to vocal stimuli. Ten% will be conscious but dazed or disoriented. Hearing loss with bleeding from affected ear possible. All will have head and neck stabilized with cervical collar; 100% will also need additional C-spine precautions including spine board, with the head elevated 15-30 degrees. Ninety% will need oral airway or intubation, with 20% requiring assisted ventilation but not *hyperventilation*. Start or maintain IV in 90%. Foley catheters in 70%, and oral gastric tubes in 60%. Seizure precautions should be taken in 100%.

OPEN HEAD WOUND: SIMPLE

Patient presents with deep laceration or avulsion of scalp, with moderate blood loss, and no loss of consciousness. Vital signs remain normal, and patient is awake and oriented. Head wound is dressed and cervical collar applied in 100%. Stabilize C-spine as needed. Start or maintain IV in 100%. Provide pain meds and reinforce dressings as needed.

OPEN HEAD WOUND: COMPLEX

Patient presents with single or multiple wounds to the head, with some fracturing and penetration of the skull, with moderate bleeding and possible eye injuries. Thirty percent will present as conscious but confused; the remainder will be comatose and respond only to painful stimuli. Eighty percent will experience tachycardia and be hypotensive. Respiration in 80% will be shallow and/or rapid, with moderate distress. Wounds will be dressed and cervical collar applied in 100%. Additional C-spine stabilization with spine board is needed in 100%. Elevate head 15-30 degrees in 30%. Start or maintain IV in 100%, with IV x 2 in 40%. Sixty percent will require intubation, with some requiring manual or mechanical ventilation. Foley catheterization in 70%, and oral or nasal gastric intubation in 70%. Place eye shield if needed, and reinforce dressings as required. Seizure precautions should be taken in 100%.

FACE & THROAT INJURIES

Patient presents with single or multiple injuries to the face and/or throat. Seventy percent will suffer facial fractures; 48% will involve lacerations or penetrating facial or neck wounds with moderate to severe hemorrhaging. All will be conscious and oriented. Wounds will be dressed and cervical collars applied to 100%. Forty percent will be hypotensive with tachycardia. Up to 60% will experience moderate to severe respiratory distress requiring airway maintenance, with a small percentage of those requiring a cricothyroidotomy to clear their airway. Additional C-spine precautions for all, including backboards. IVs in 90%. Reinforce dressings as needed.

BURNS

Patients will present conscious, alert and oriented, but in severe pain from partial or full thickness burns up to 40% BSA. A small percentage will be litter patients. Approximately 30% of the patients will experience tachycardia and/or respiratory distress, with 14% requiring intubation and oxygen. Ninety percent will require IVs, 26% Foley catheterization, and 14% nasogastric intubation. Clean and dress or reinforce dressings on all burns, using water gel dressings on white phosphorus burns. Provide pain medications as required.

SIMPLE PENETRATING WOUNDS

Patient presents with single or multiple penetrating wounds to the extremities or buttocks with minimal to moderate bleeding, without fractures or other complications. All will be conscious, with one third presenting as litter patients. Less than 20% will be slightly tachycardic and/or hypotensive. Half will require IV. Wounds will be dressed, but may require additional hemorrhage control, reinforcement, or splinting. Pain medications as needed.

WOUNDS WITH FRACTURES

Patients will present with open wounds of the extremities from blast effects, penetrating weapons or crush effects, with moderate to severe damage to the bones and cartilage. Sixty percent will suffer moderate to severe bleeding. Sixty-five percent will be litter patients. Approximately 30% will be hypotensive and/or experiencing tachycardia. Wounds should be dressed but may require additional control of hemorrhaging, including tourniquets and reinforcement of dressings. Splint or use sling and swathe as necessary. IV in 80%, with 25% requiring two IVs. Pain meds in all cases.

CLOSED FRACTURES

Patient presents conscious and alert but in pain from closed injury to the extremities, shoulder girdle, or ribs. Obvious deformity will be seen in 25% of the injuries; the rest will present only pain and/or swelling. Forty percent will be litter patients. Fifteen percent will be hypotensive and experiencing tachycardia, and will require one or two IVs. Sling and swathe for shoulder and rib injuries. Splint arm and hand injuries, plus sling and swathe if possible. Splint minor leg injuries; traction splint for femur fractures. Pain medications as needed.

CLOSED FRACTURE, PELVIC

Litter patient presents with severe pelvic pain and tense abdomen. Those with displaced fractures will be apprehensive with shallow respirations, tachycardia and decreasing blood pressure. Establish two IVs and place patient in pelvic sling, spine immobilization and nasogastric intubation. Those without displaced fractures will only require spine board immobilization and one IV. Pain medication as needed for all.

SUPERFICIAL CHEST WOUND

Ambulatory patient presents with open wound to the anterior or posterior thorax with minimal to moderate hemorrhaging. Vital signs are stable. Wound may require debridement if not performed in the field. Otherwise, wound will be cleaned and dressed, requiring only reinforcement of dressings. Establish or maintain IV in those with moderate bleeding. Administer pain medications as needed.

CHEST & ABDOMEN WOUNDS WITH PNEUMOTHORAX

Litter patient presents with moderate to severe respiratory distress secondary to closed (blast, crush) injury or multiple penetrating wounds to the thorax and abdomen. Patient will be alert but apprehensive, with tachycardia and unstable blood pressure. Breathing is rapid and shallow, with diminished breath sounds on one side. Decompress affected side of chest and administer oxygen, intubating if necessary. IVs in 100%. Pain medications as needed. Dress open wounds or reinforce dressings as required.

ABDOMINAL AND GENITALIA WOUNDS

Patients will present with complaint of pain, tenderness and/or distension in the abdominal or genital region from open, penetrating or crushing wounds. Eighty% will be litter patients. Thirty-five percent will suffer moderate to severe hemorrhage. All patients will be alert and oriented, with 40% experiencing agitation or apprehension. Seventy percent will experience moderate to severe tachycardia and hypotension, and respirations will be rapid and shallow in 40%. IVs will be required for 90%, with half of those needing two lines. Control hemorrhage and dress wounds, or reinforce bandages on wounds already dressed. Nasogastric tubes in 60% and Foley catheters in 40%. Pain medication as needed.

ABDOMINAL WOUND WITH EXTREMITY FRACTURE

Litter patient presents with multiple injury penetrating wounds to the abdomen and extremities, complicated by fractures of the limbs or pelvis. Patient will be alert and agitated or apprehensive, with moderate to severe tachycardia and hypotension. Place two IVs, a nasogastric tube and Foley catheter in all. Control hemorrhage, dress wounds or reinforce dressings, and splint fractures. Pain medications as needed.

ABDOMINAL WOUND WITH PELVIC FRACTURE

Litter patient presents with multiple penetrating wounds to the abdomen with fractures of the pelvic bone and accompanying organ damage. Abdomen is tense, tender and possibly distended. Respirations are rapid and shallow, with moderate tachycardia and hypotension. Place two IVs and nasogastric tube. Dress wounds or reinforce bandages. Stabilize pelvis with pelvic sling and spine board. Pain medications as required.

CHEST AND ADOMINAL WOUNDS

Litter patient presents unconscious with multiple penetrating wounds to chest and abdomen, with extensive damage to internal organs. Vital signs are unstable with tachycardia and dropping BP unresponsive to fluid resuscitation. Respirations are shallow, rapid, and distressed. Stomach is rigid and distended. Establish/maintain patent airway and two IVs. Dress wounds or reinforce bandages. Patient is expectant. Morphine or sedation for comfort.

ABDOMINAL CRUSH INJURIES

Litter patient presents with tender, distended, or tense abdomen from a crush or blunt force injury with probable damage to the liver or spleen. Patient's vitals will range from mild tachycardia and hypotension to severe hypotension with heart rate greater than 140. Those with acute injury will be apprehensive, with shallow respirations. IVs in all, with two lines and nasogastric intubation for the most severely injured. C-spine immobilization and pain medication as needed.

COLD INJURIES (EXTREMITIES)

Patient presents complaining of cold, pain and/or numbness of the feet or hands. Fifty percent will be litter patients. Trench foot patients will present with white, hydrotic "dish-pan" appearance of the feet, with vesicle formation and maceration in severe cases. Frostbite patients will present with splotchy skin in affected areas; skin in severe cases will be hardened, blanched and may appear dead. Protect affected areas from further cold or trauma. Place 2x2 dressings between fingers or toes, and wrap affected extremities in dry, sterile bulky dressings. Do not rub affected areas or attempt to rewarm.

COLD INJURIES (SEVERE HYPOTHERMIA)

Litter patient presents as unconscious, responding only to painful stimuli, extremely hypotensive with slow, weak pulse and slow respirations (8-10 per minute). Skin is pale and cold to the touch. Maintain airway with oropharyngeal airway or ET intubation. Nasogastric tube and Foley catheterization. Place IV, using warmed fluids if available. Wrap in blankets or sleeping bag.

HEAT STROKE

Litter patient presents comatose and responding only to pain, severely hypotensive with tachycardia, and shallow, rapid respirations. Body temperature is more than 105° F. Place two IVs, a Foley catheter, and an oral airway or ET tube. Cool with chemical cold packs or any other means available. Provide high-flow oxygen via nonrebreather mask.

NEAR DROWNING

Litter patient presents in stuporous condition, with rapid, irregular heartbeat, mild hypotension, and rapid shallow spontaneous respiration. Temperature is normal. CPR was initiated in the field. Provide oxygen by nonrebreather mask and insert IV. Dry and warm if patient is still wet.

SNAKE BITES

Patient is ambulatory with assistance, with bite on extremity. If not done in the field, clean and dress wound and place constrictive bands above and below the bite. Splint extremity and mark bite site to watch for swelling. Watch vital signs for indication of shock, and provide high-flow oxygen via nonrebreather mask if necessary.

INSECT BITE (ANAPHYLAXIS)

Ambulatory patient presents with rapid, shallow, and labored breathing, rapid heart rate and hypotension, and apprehension. Place IV and manage airway. Provide SQ epinephrine and oral or IV diphenhydramine, and, if available, albuterol inhalant. Provide oxygen via nonrebreather mask.

EYE INJURIES

Ambulatory patient presents with isolated eye injury from debris (laceration or abrasion) or directed energy source (laser). Minimal or no hemorrhage. Vital signs are stable. Place protective eye shield as needed, without applying pressure to the eye. Pain medications as needed.

AMPUTATIONS

Litter patient presents with grossly mangled or missing extremity or limb. Moderate to severe hemorrhage, depending on the amount of the limb missing or damaged. Vital signs reveal moderate to severe shock secondary to blood loss. If not done by field medic, control hemorrhage with tourniquet (if partial limb remains) and/or apply field dressing with fluffed gauze over stump. Otherwise, re-evaluate tourniquet and reinforce dressings. Start or maintain IV; start second IV in those with most severe bleeding. Pain medications as needed.

TOXIC INHALATION

Litter patient presents with tachycardia, slight hypotension, and tachypnea with or without wheezes or stridor. Start or maintain IV fluids. Intubate and provide oxygen. Pain medications (morphine) as needed.

ACUTE ABDOMEN

Patient presents with regionalized pain and tenderness in abdomen or groin, and possibly the scrotum, associated nausea and/or vomiting, and, in most cases, an elevated temperature. Pain may have been present for days, with no associated injury. In the case of inguinal hernia, a bulge may present in the lower abdomen. Vital signs are otherwise stable. Establish IVs in 70% and nasogastric tubes in those with vomiting and fever.

REGIONAL DISEASES

Ambulatory patient presents complaining of severe headache or diarrhea, accompanied by elevated temperature, mild hypotension, chills and shakes, or altered mental status. Evaluate and treat symptoms.

Establish IV as needed.
COMBAT STRESS
Ambulatory patient presents with signs and symptoms of severe stress reaction, including anxiety, depression, sleepless, conversion disorder, or dissociative behavior. Evaluate patient and assess for risk of harm to self or others. Restrain as necessary.
RESPIRATORY DISEASE
Patient presents with complaints of difficulty breathing, with moderate to severe wheezing. Vital signs are stable. Patient is alert and oriented, but may be apprehensive. Patient may have history of asthma, but meds used in the past are not effective at controlling symptoms. Start IV, place on oxygen via nonrebreather mask. Albuterol inhaler as needed. Epinephrine in 10%.
ISCHEMIC CHEST PAIN
Patient presents with complaint of severe, crushing chest pains located in the center of the chest radiating to either arm and shoulder, shortness of breath and palpitations, and nausea and diaphoresis. Blood pressure around 160/110 and tachy pulse around 115. Start or maintain IV, give ASA, high-flow oxygen by nonrebreather mask, morphine and sublingual or spray nitroglycerine. Attach to monitor if available.

REPORT DOCUMENTATION PAGE

The public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing the burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to any penalty for failing to comply with a collection of information if it does not display a currently valid OMB Control number. **PLEASE DO NOT RETURN YOUR FORM TO THE ABOVE ADDRESS.**

1. Report Date (DD MM YY)
August 2003

2. Report Type
Final

3. DATES COVERED (from - to)
2003

4. TITLE AND SUBTITLE

Marine Corps CASEVAC: Determining Medical Supply Requirements for Long-Range Casualty Evacuation Aircraft

6. AUTHORS

Hill, Martin; Michael Galaraneau, Paula Konoske, & Gerry Pang

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

Naval Health Research Center
P.O. Box 85122
San Diego, CA 92186-5122

8. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

Chief, Bureau of Medicine and Surgery
Code M2
2300 E St NW
Washington DC 20372-5300

5a. Contract Number:

5b. Grant Number:

5c. Program Element: 63706N

5d. Project Number: M0095

5e. Task Number: 005

5f. Work Unit Number: 60120

9 PERFORMING ORGANIZATION REPORT NUMBER

Report No. 03-20

10. Sponsor/Monitor's Acronyms(s)

BuMed & MARCORSYSCOM

11. Sponsor/Monitor's Report Number(s)

12. DISTRIBUTION/AVAILABILITY STATEMENT

Approved for public release; distribution unlimited.

13. SUPPLEMENTARY NOTES

14. ABSTRACT (maximum 200 words)

Providing casualty evacuation (CASEVAC) in the modern high-maneuver combat environment presents special problems. Small mobile units operating at increased distances from rear areas or sea-based platforms likely will not have the support of a Level 1B treatment facility, such as a battalion aid station. With combat elements positioned far forward of their support units, ground evacuation may be impractical. Even evacuation by air may take more than the "Golden Hour" by which time trauma experts agree severely injured patients must receive some form of advanced lifesaving intervention. Needed is a specially equipped aeromedical asset manned by corpsman with appropriate skill levels to provide the necessary critical care interventions to stabilize severely wounded, injured or ill Marines for a period of transit that could last hours. The objective of this study was to determine what level of medical skills and what kind of medical equipment would be required for such a CASEVAC asset.

15. SUBJECT TERMS

CASEVAC, casualty evacuation, aeromedical, critical care, combat medicine

16. SECURITY CLASSIFICATION OF:

a. REPORT
UNCL

b. ABSTRACT
UNCL

b. THIS PAGE
UNCL

17. LIMITATION OF ABSTRACT
UU

18. NUMBER OF PAGES
39

19a. NAME OF RESPONSIBLE PERSON
Commanding Officer

19b. TELEPHONE NUMBER (INCLUDING AREA CODE)
COMM/DSN: (619) 553-8429